REINHOLD ENVIRONMENTAL Ltd.

RE

2017 NOx-Combustion-CCR Round Table Presentation

February 27 & 28, 2017, in Cleveland, OH / Hosted by FirstEnergy

THE CARE AND FEEDING OF YOUR HYDRATED LIME SYSTEM

MISSISSIPPI LIME

DISCOVERING WHAT'S POSSIBLE WITH CALCIUM

Curt Biehn & Randy Griffard

Reinhold Environmental – NO_x Combustion – CCR

Workshop 13 – February 28, 2017

MISSISSIPPI™ LIME

Discovering what's possible with calcium

WHY IS FEED CONSISTENCY IMPORTANT?

Safety: Reduced exposure risks

- Eye injuries (number and severity)
  - Plugged and pressurized lines/lances
    - Use two people to troubleshoot
- Strains
  - Pulling lances
  - Feeder maintenance

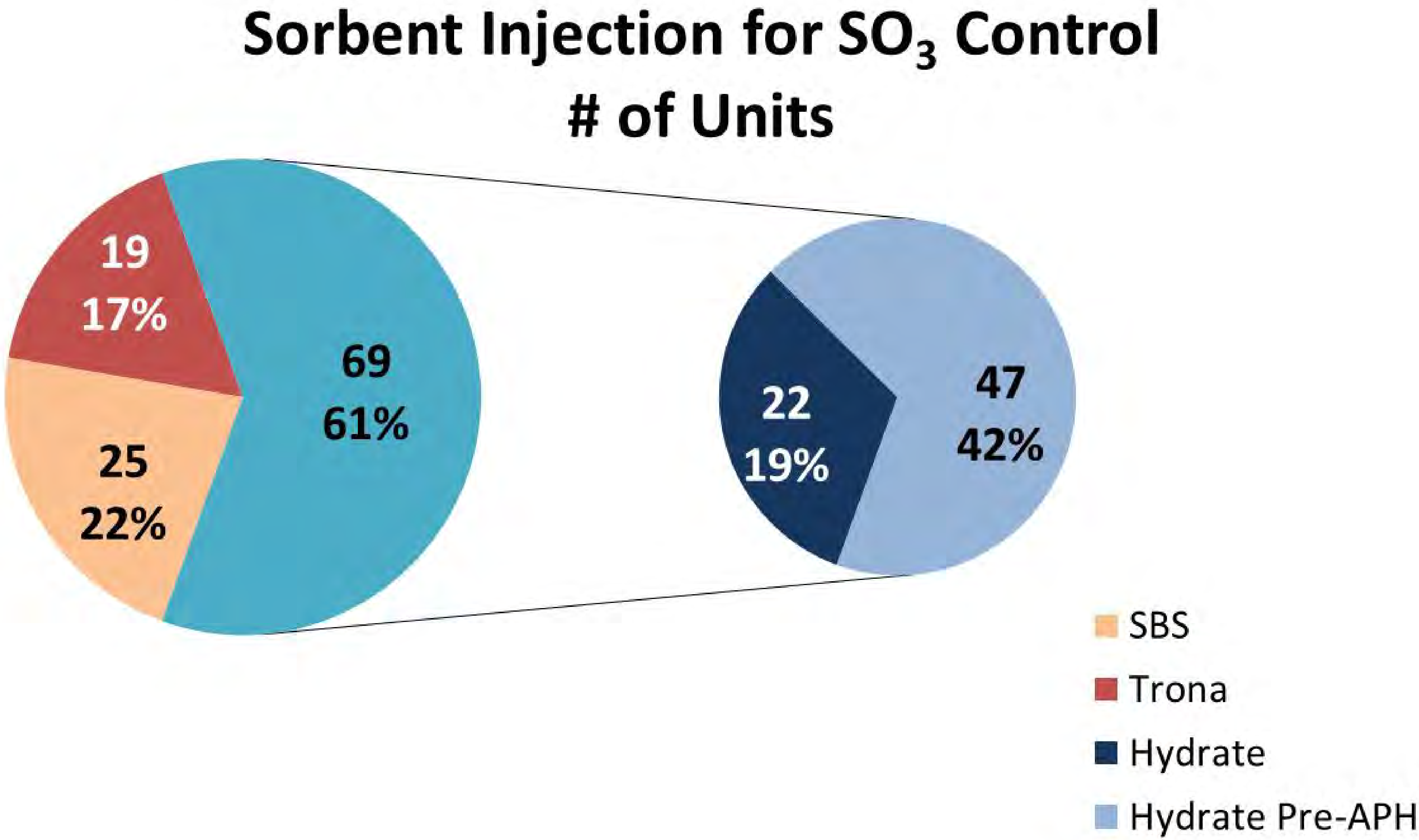
WHY IS FEED CONSISTENCY IMPORTANT?

- Reduced staffing to deal with flow issues
- Consistent performance requirements
  - Consent decrees
    - Low SAM limits
  - MATS
    - 90%+ HCl removal
    - SO_3 reduction prior to Hg removal
  - Heat rate gains
    - Low SO_3 levels for low APH outlet temperature

BENEFITS OF USING HYDRATED LIME FOR DSI

- Proven for SO_3, HCl & SO_2
  - Help utilities meet Hg MATS
- Simple Systems
- Cost Effective
- Leachable salts not an issue

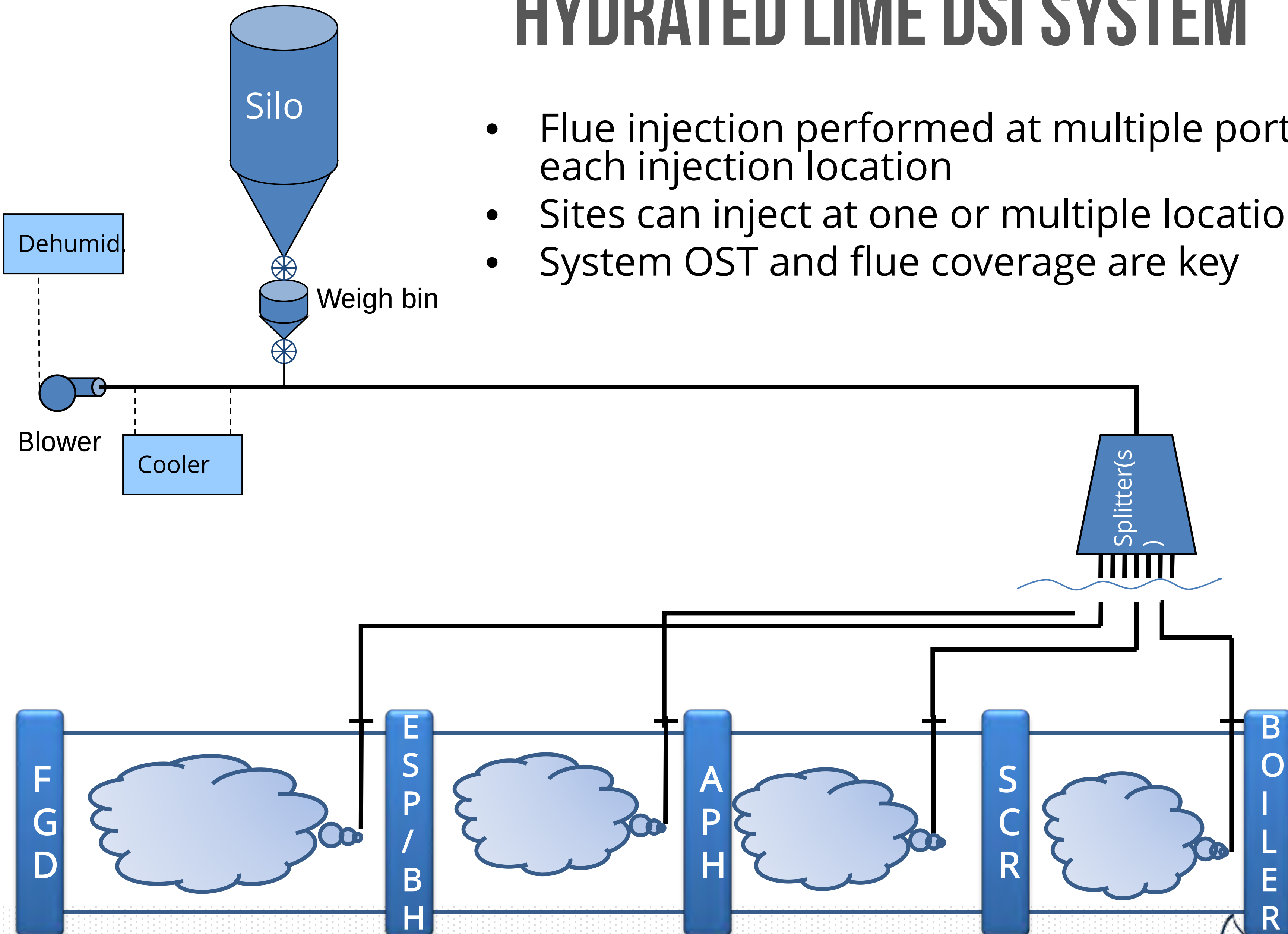
UTILITY CONTROL OF SO_3



Similar distribution if grouped by MW

HYDRATED LIME DSI SYSTEM

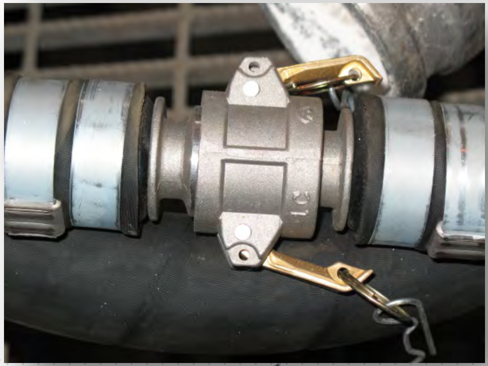
- Flue injection performed at multiple ports in each injection location
- Sites can inject at one or multiple locations
- System OST and flue coverage are key



EVOLUTION OF HYDRATED LIME DSI (PRIOR TO 2010)

Many systems installed in mid-2000's

- Steep learning curve
  - Blockage (powder)
  - Scaling ($CaCO_3$ formation)
- Trial systems problematic



J. Wilson, DHUG, 2010

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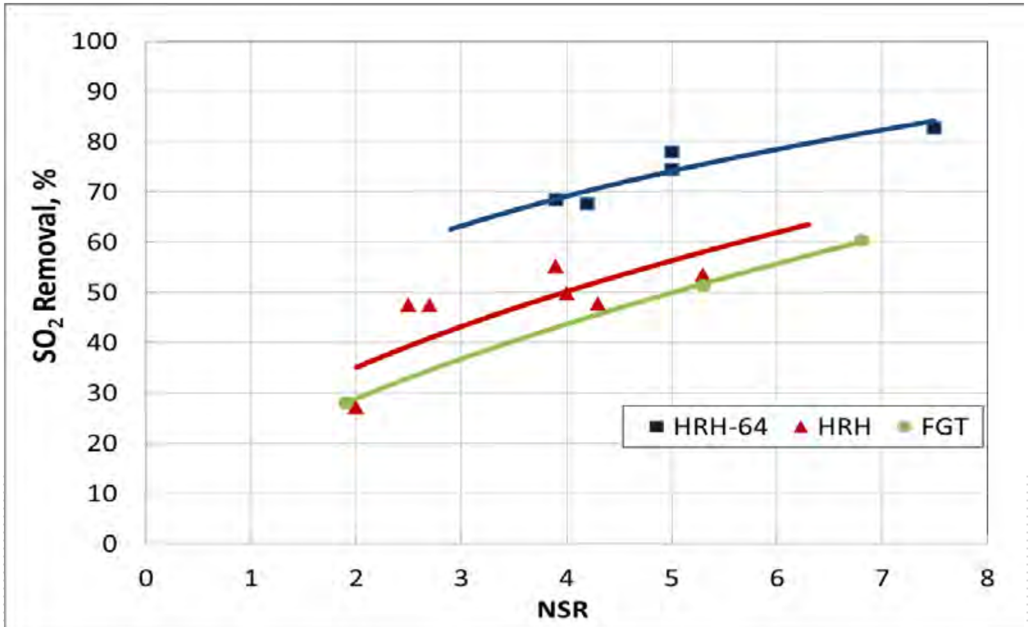
EVOLUTION OF HYDRATED LIME DSI (2010-PRESENT)

- Improved understanding of key factors
  - Keep hydrate in suspension while controlling scale buildup
- Better trial systems
- Improved distribution in flue gas
  - Lances & mixing devices



- Enhanced hydrated limes offer improved performance

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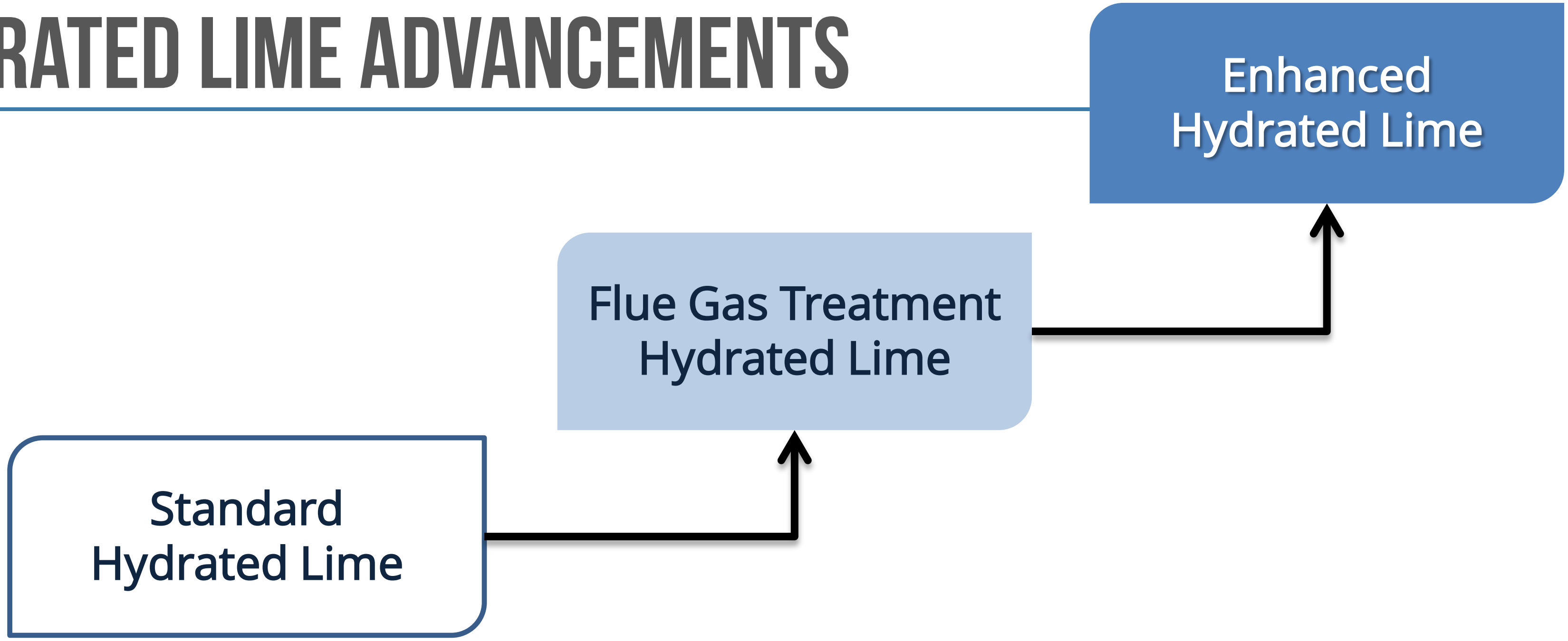
HYDRATED LIME ADVANCEMENTS



- Enhanced hydrates: Higher performance and/or lower annual delivered cost savings
- Physical differences between grades and suppliers
  - Bulk density
  - Particle size
  - Flow characteristics

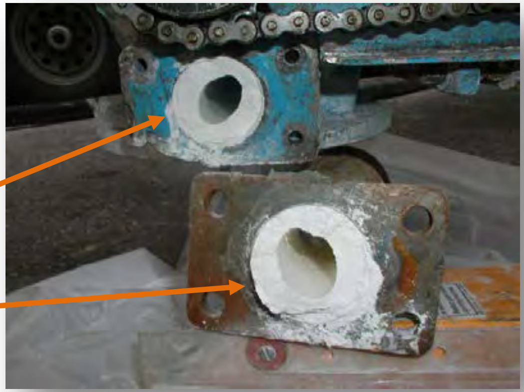
CONVEYING AIR QUALITY

EARLY CHALLENGE – CARBONATE SCALE AT VALVE DISCHARGE

- Reaction forms a hard scale of calcium carbonate

$$Ca(OH)_2 + CO_2 \xrightarrow[H_2O]{Heat} CaCO_3 + H_2O$$

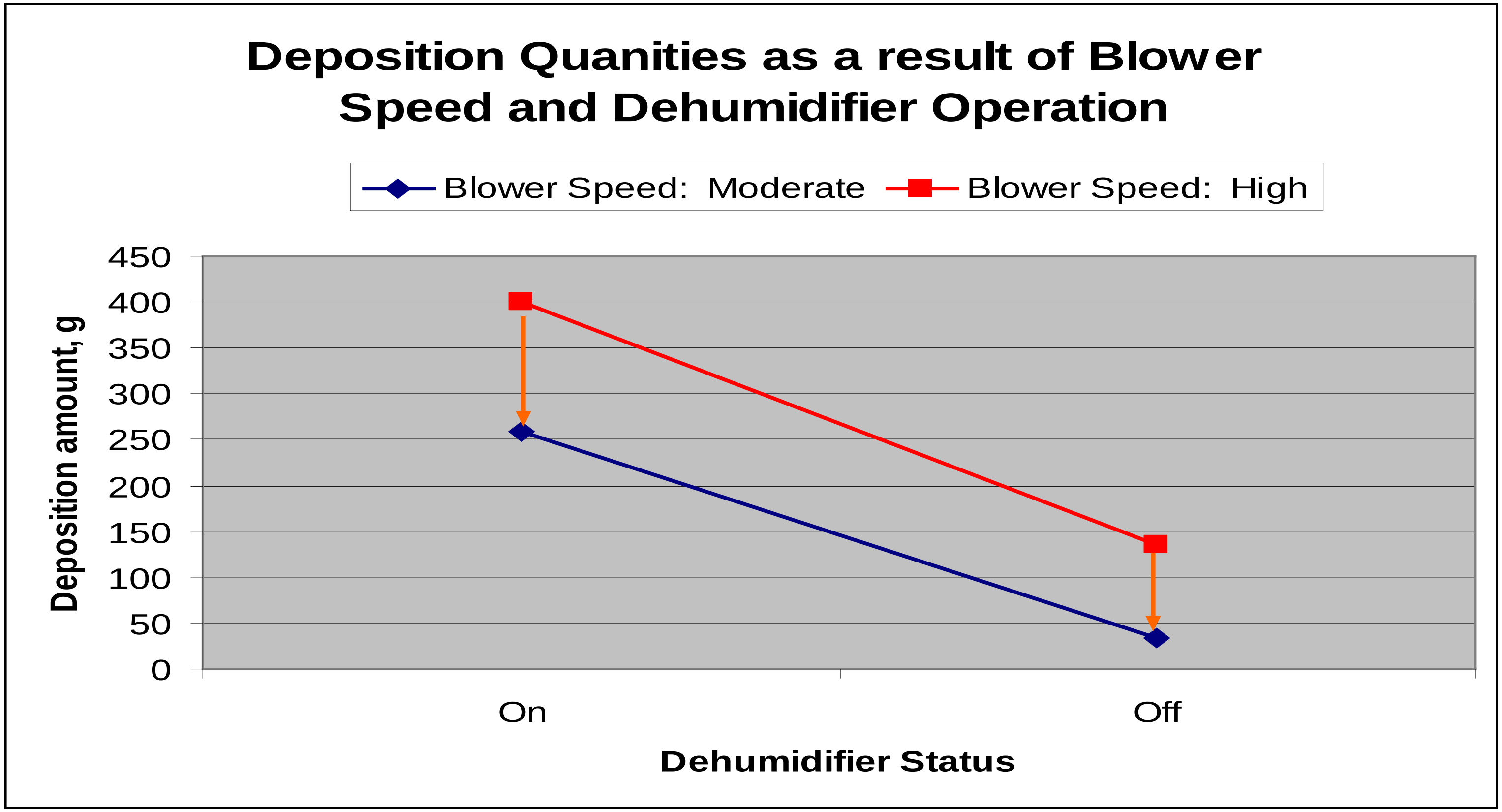
- Occurs at initial air/hydrate contact on dilute phase systems
  - Close to rotary airlock or first elbow
  - Typically not evident downstream



Calcium carbonate scale generated at MLC's Ste. Genevieve R&D facility

TVA WIDOWS CREEK RESOLUTION

OPTIMIZE AIR FLOW AND TEMPERATURE

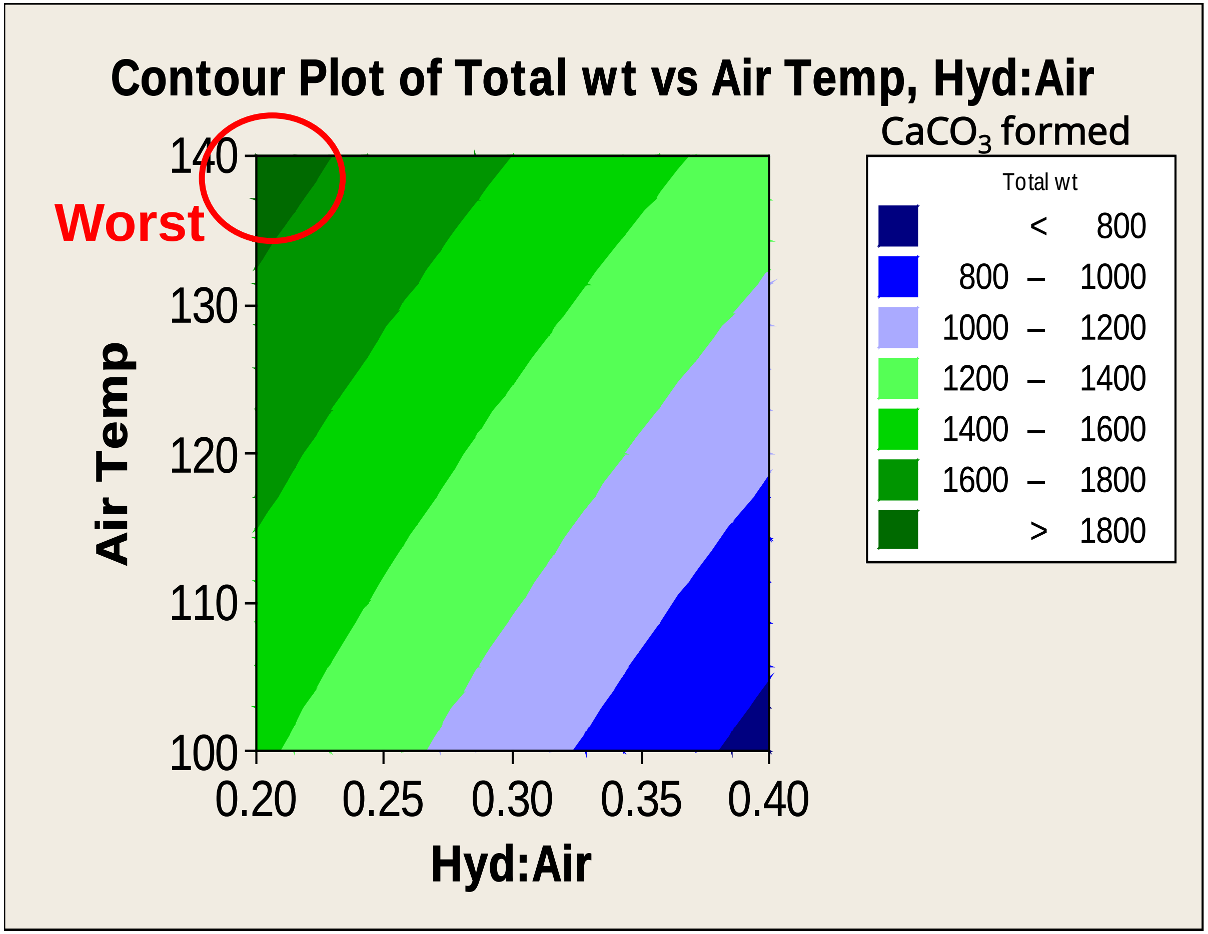


Minimize deposits using controlled air flow without the need to dehumidify

Presented at 2008 APC Conference

R&D Test System – Design of Experiments - 2010 Conclusions

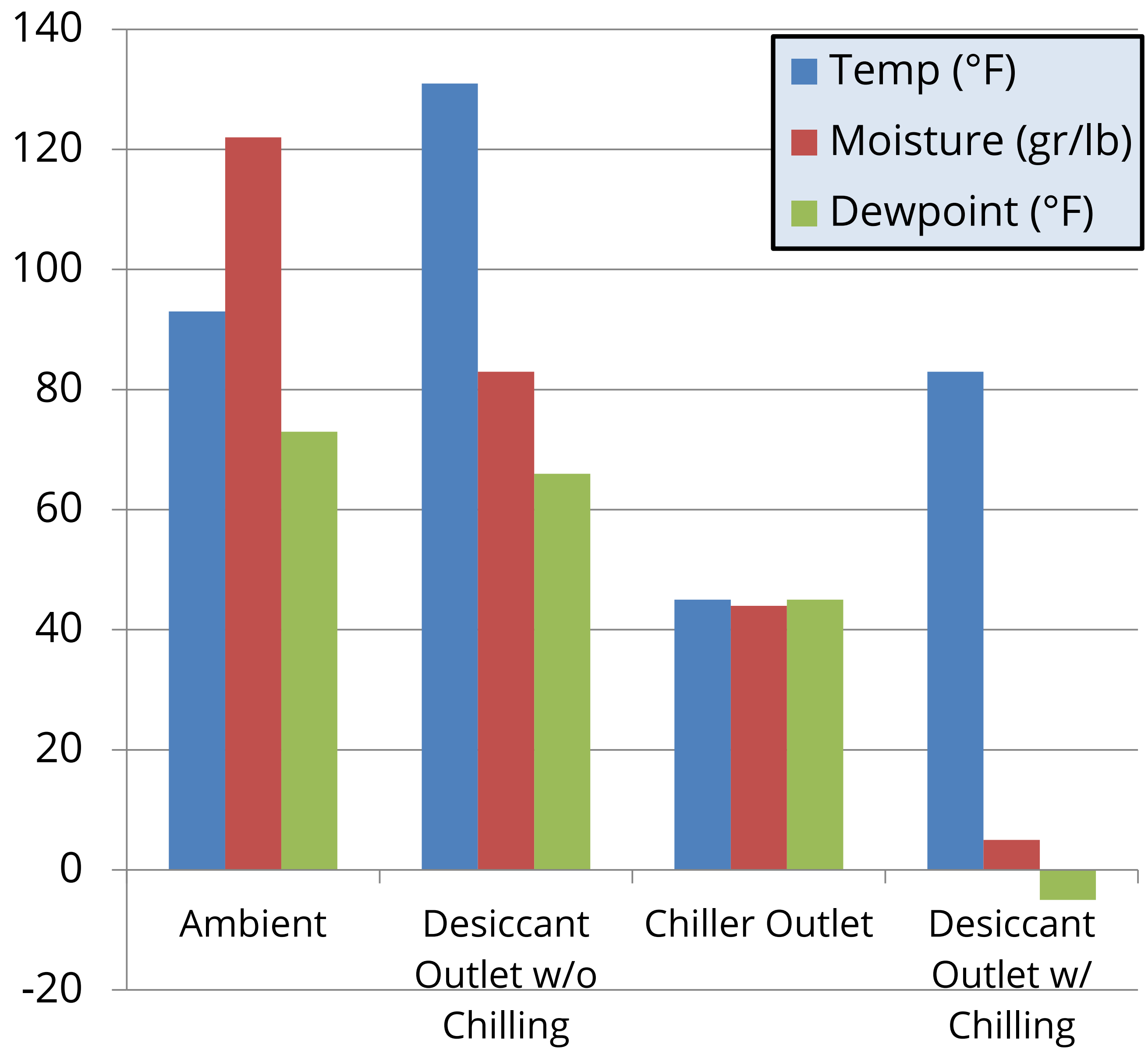
- Low Hydrate:Air systems are prone to scale formation
- Higher Temperature drives scale formation



Presented at 2010 APC Conference

CONVEYING AIR QUALITY *(DONNER , DUKE ENERGY; 2015 APC CONF)*

- Pre-chilling + desiccant dryer is very effective means of moisture removal
- Dewpoints near dry compressed air quality
- Greatly reduces the possibility of having a “Condensation Event”



WIDE OPERATING SPECS CAN CAUSE HEADACHES

Assume 500 MW plant specifying operating range of 20-50 ppm SO_3 at injection point

(380 SCFM blowers, 4” main convey line, 4 psi operating pressure)

At 50 ppm SO_3: Estimate 1,140 lb/hr hydrate (two ducts)

Pickup velocity = 3,425 ft/min (good)

lbs Hydrate:lbs Air = 0.62 (good)

At 20 ppm SO_3 : Estimate 456 lb/hr hydrate (two ducts)

Pickup velocity = 3,425 ft/min (good)

lbs Hydrate:lbs Air = 0.25 (risky)

Reduce blower to 300 SCFM:

lbs Hydrate:lbs Air = 0.31 (a little better)

P/U velocity = 2,700 ft/min (risky; near saltation velocity)

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POST-SPLITTER AIR FLOW

- Stay above saltation velocity between splitter and lances
- If below saltation, dry powder plugs form
  - No injection at that lance until plug is cleared

<u>Chart</u>

6 lances, 3 options on diameter

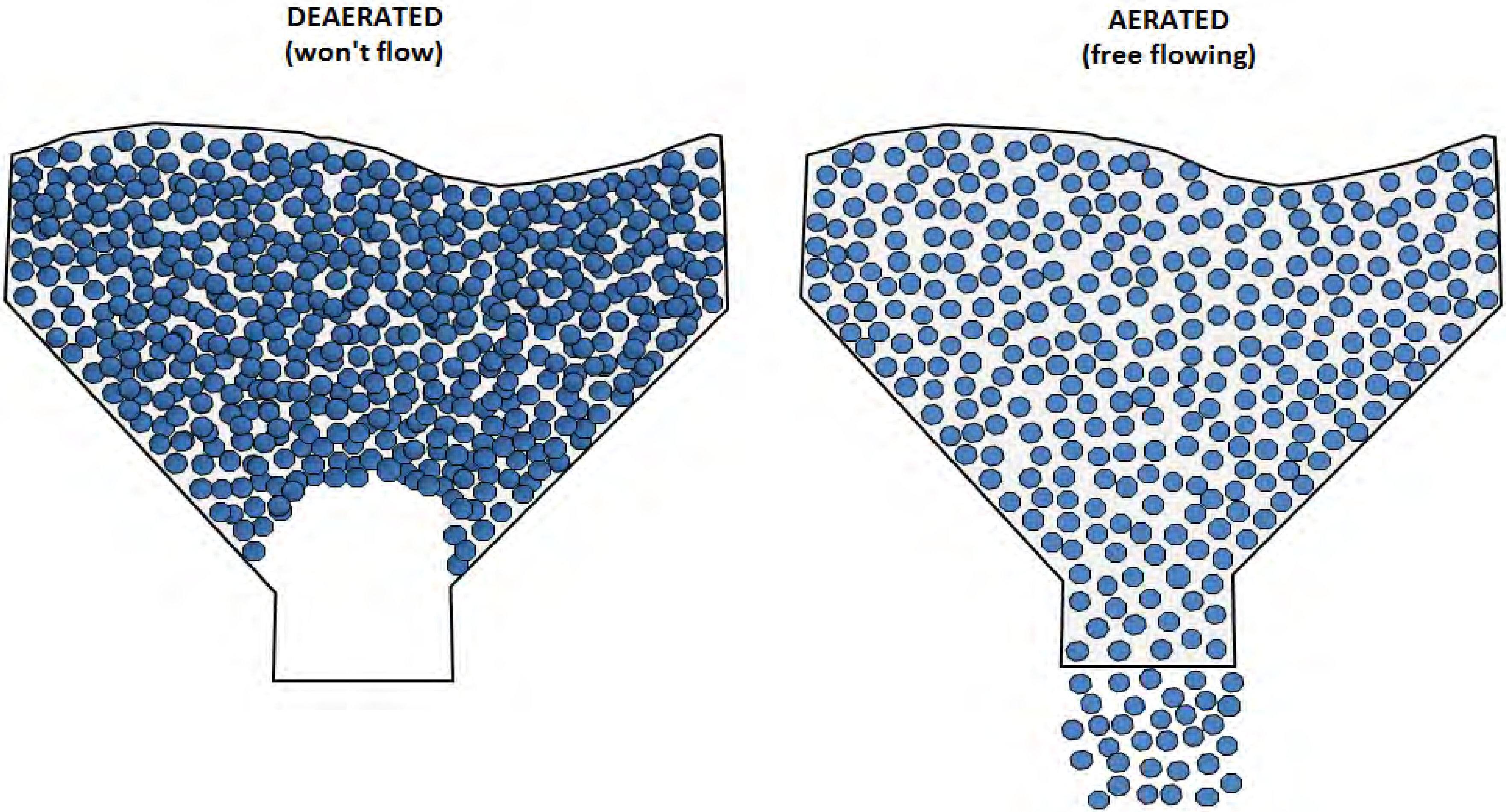
< 2400 ft/min -> bad

2400 – 3300 -> not optimal

>3300 ft/min -> good

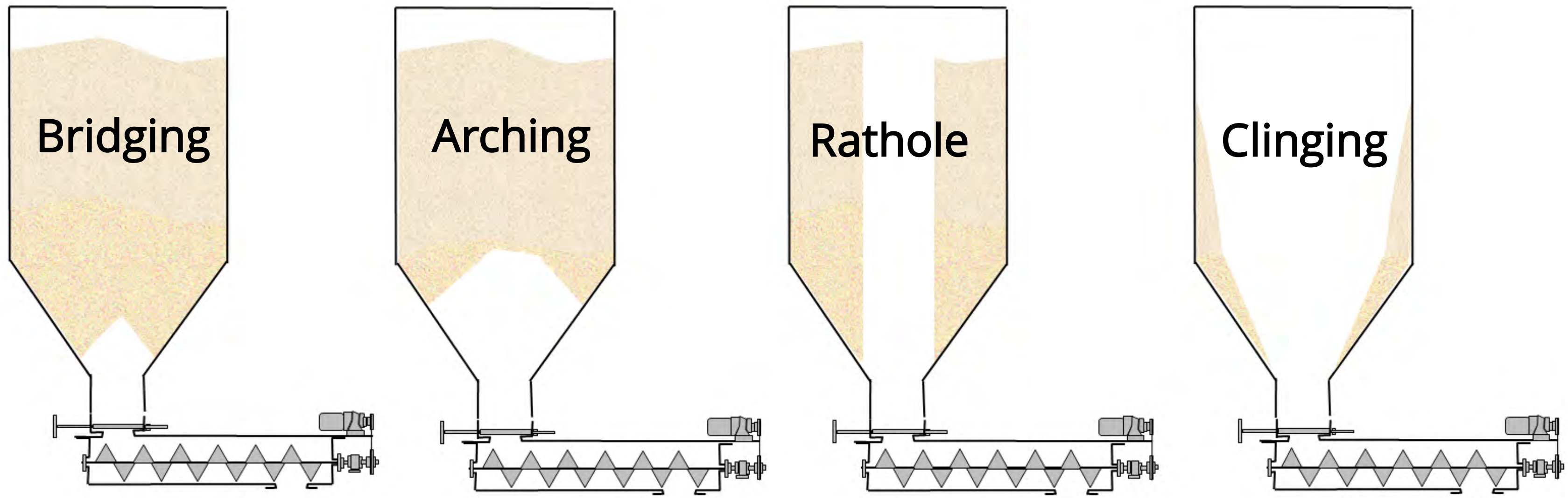
>5000 ft/min -> too much air; potential $CaCO_3$ formation

Velocities In Line (Std Wall Sch 40)			
Pipe Size	**1.25**	**1.5**	**2.0**
Pipe Dia. (I.D.)	1.380	1.610	2.067
Sq Ft	**0.0104**	**0.0141**	**0.0233**
# of Lines	6	6	6
Total Sq Ft	**0.0623**	**0.0848**	**0.1397**
150	2,408	1,769	1,073
170	2,729	2,005	1,216
190	3,050	2,241	1,360
210	3,371	2,477	1,503
230	3,692	2,713	1,646
250	4,014	2,949	1,789
270	4,335	3,185	1,932
290	4,656	3,420	2,075
310	4,977	3,656	2,218
330	5,298	3,892	2,361
350	5,619	4,128	2,505
370	5,940	4,364	2,648
390	6,261	4,600	2,791
410	6,582	4,836	2,934
430	6,903	5,072	3,077
450	7,224	5,308	3,220
Blower Output SCFM	**Feet Per Minute Velocities**		

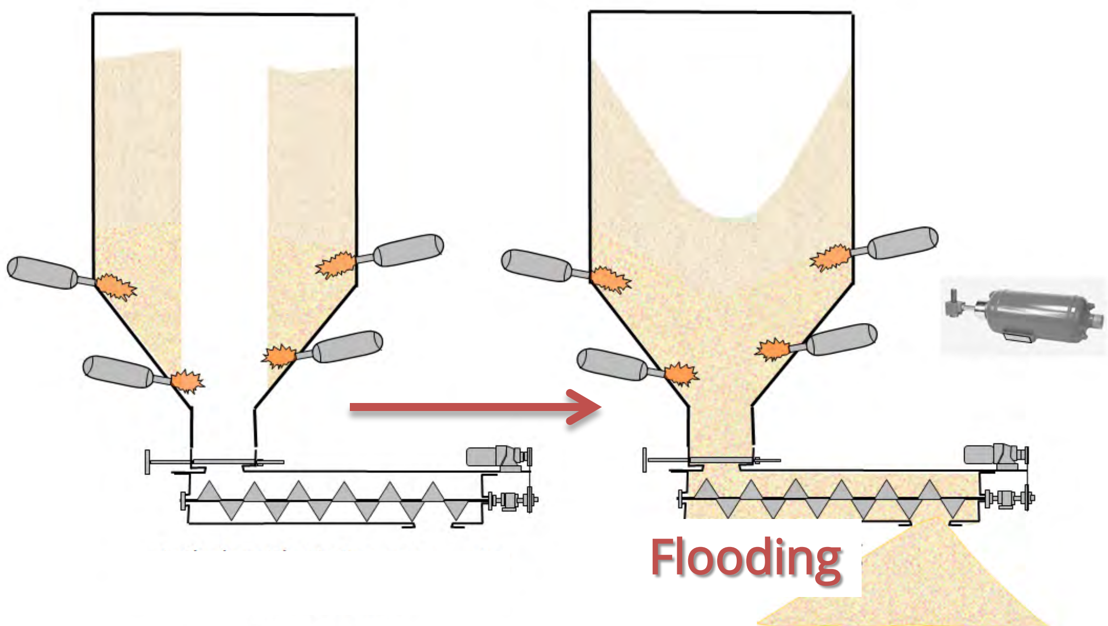


SILO RELEASE AND MATERIAL FLOW

MATERIAL FLOW CHALLENGES



Rathole with air cannons to promote flow



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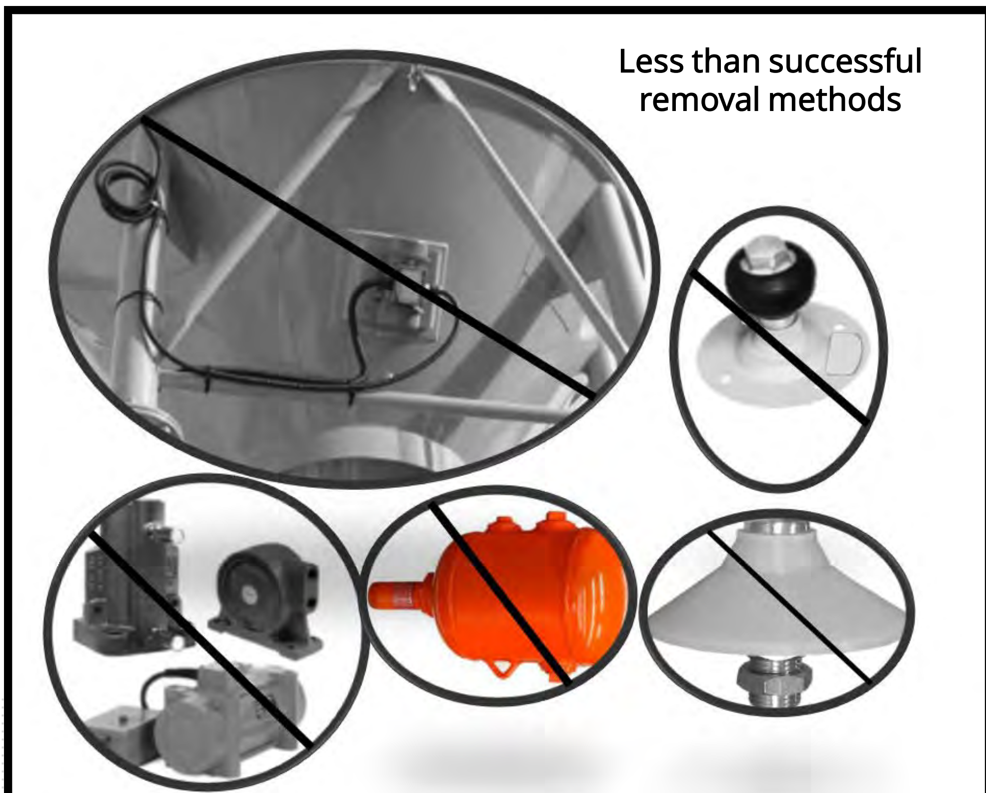
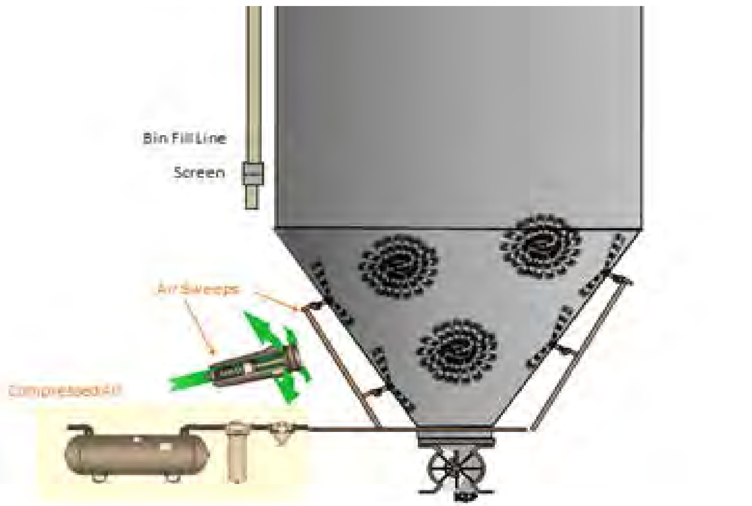
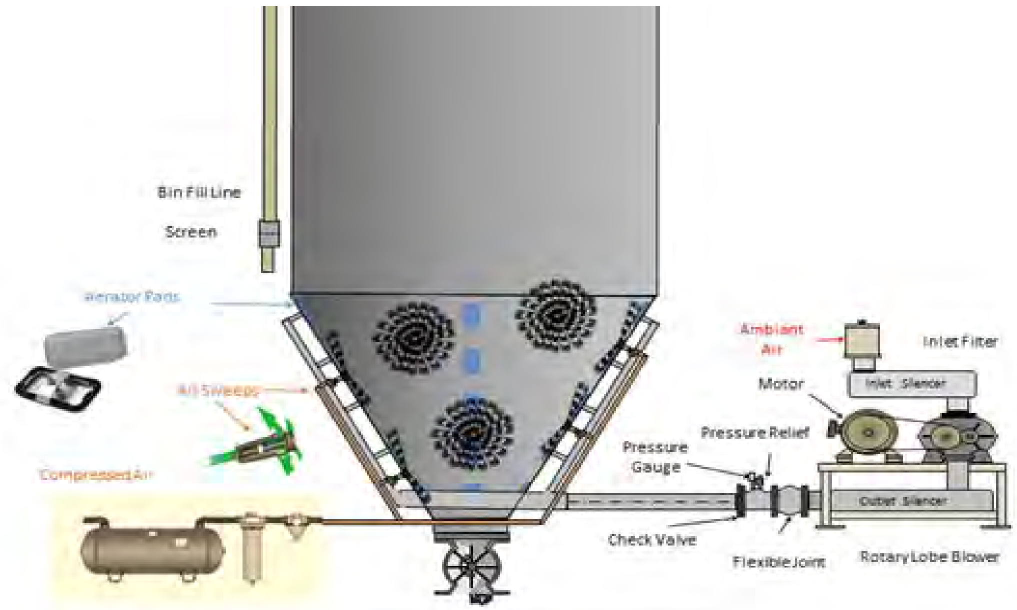
NOT THE BEST PRACTICES



IMPROVE CONSISTENCY OF MATERIAL FLOW



Storage Silo + Air Sweeps

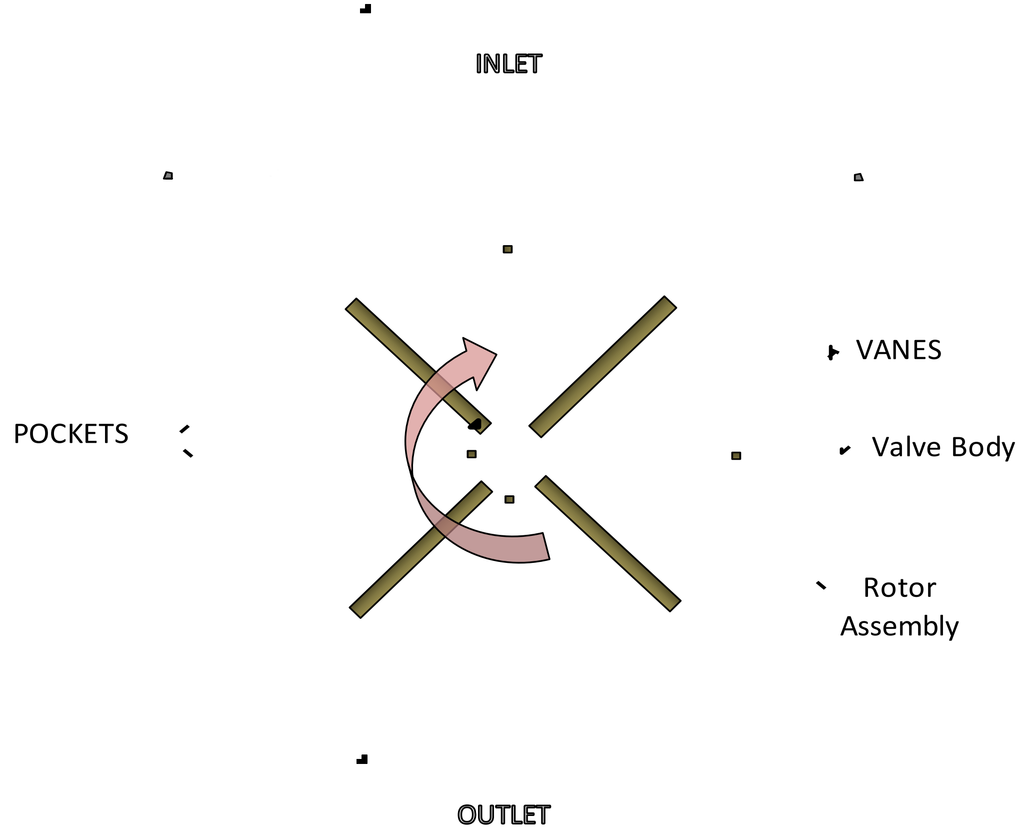


Storage Silo + Air Sweeps + Air Pads

1. Air sweeps break bridges that may form due to cohesiveness of hydrate
2. Addition of air pads gives a consistent bulk density of hydrate entering the feeder

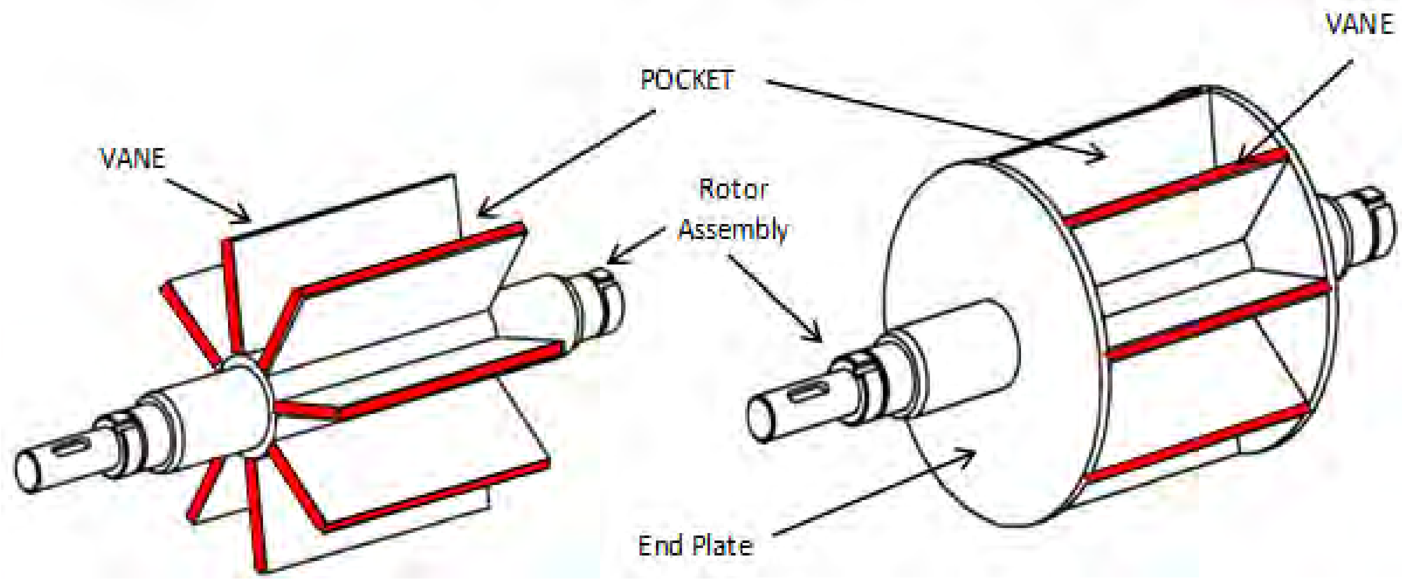
MATERIAL FLOW SUMMARY

- Screw feeders
  - Potential for flooding safety hazard when hydrate is fluidized
- Rotary feeders
  - High pressure pulses break bridges etc.
  - Air pads minimize bulk density variations
    - ➢ Consistent feed rates



ROTARY AIRLOCK FEEDERS

OPEN VS CLOSED END ROTORS



<u>Open End Rotor</u>

Three contact points with housing

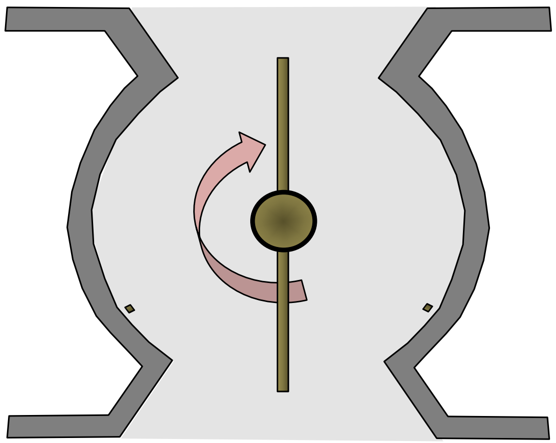
- Prone to air leakage
- Prone to wear
- Prone to squealing

<u>Closed End Rotor</u>

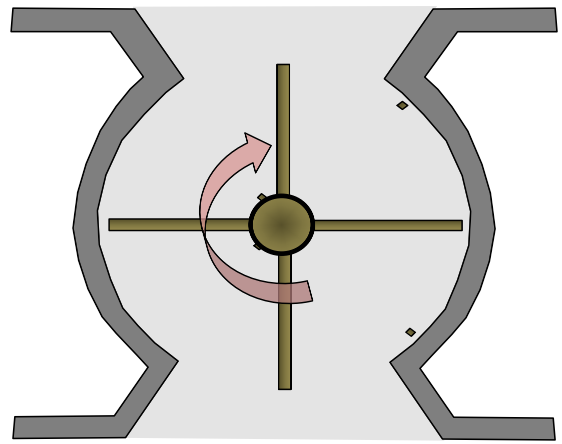
One contact point with housing

- Tighter clearances
- Reduced wear & leakage
- **Recommended for hydrate**

ROTARY FEEDERS – VANE CONFIGURATIONS

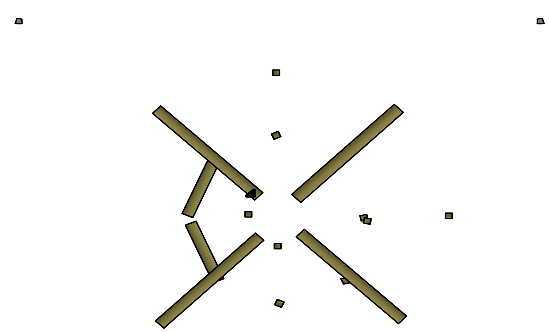


6 vane rotor



8 vane rotor

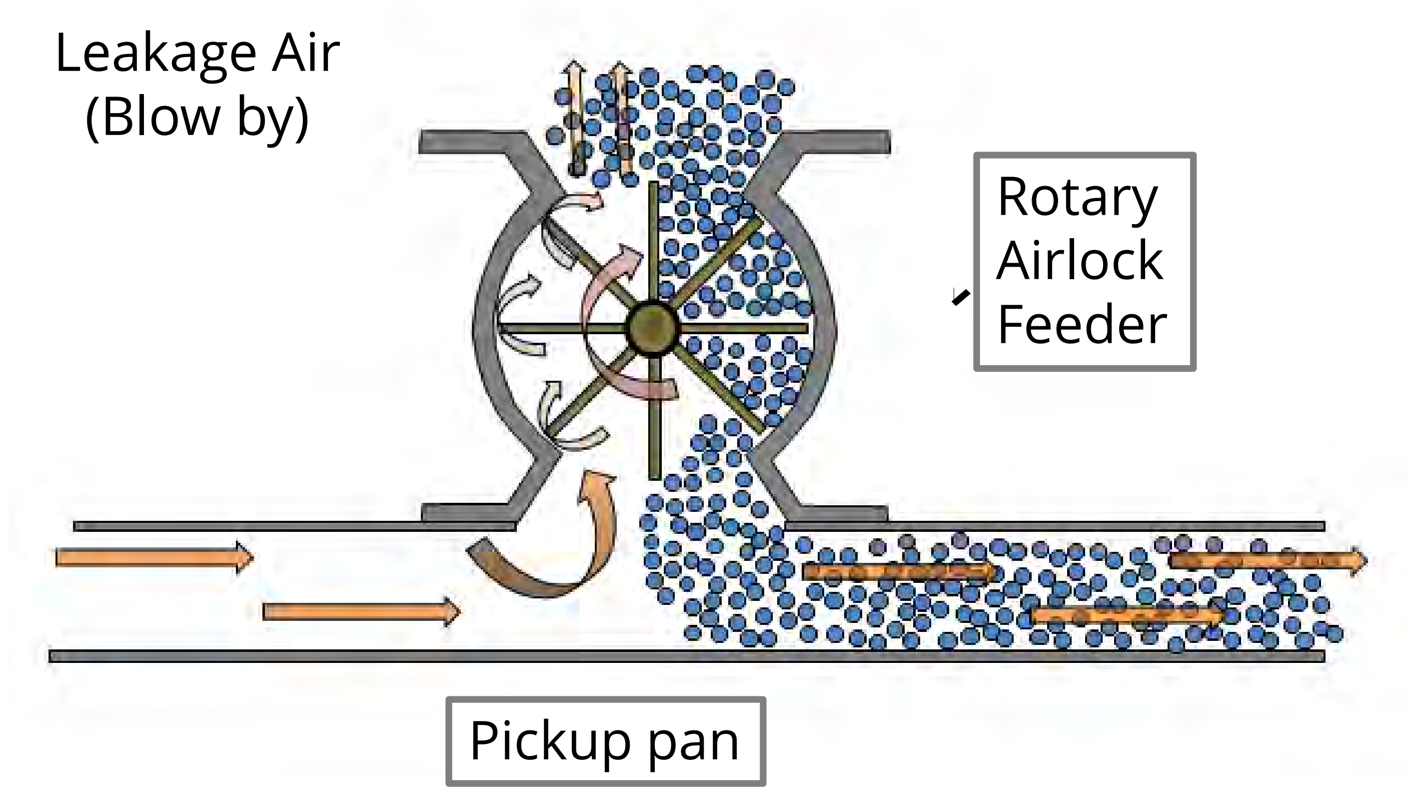
10 vane rotor



8 vane rotor shallow pocket

- Vanes increase sealing capability of the feeder
- Fewer vanes increase % pocket fill
- Shallow pocket valves good for reduced feed rates

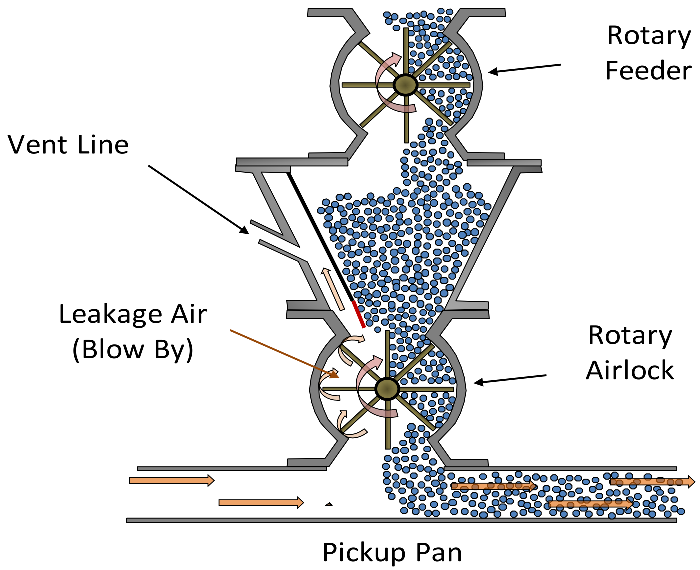
ISSUE – LEAKAGE AIR



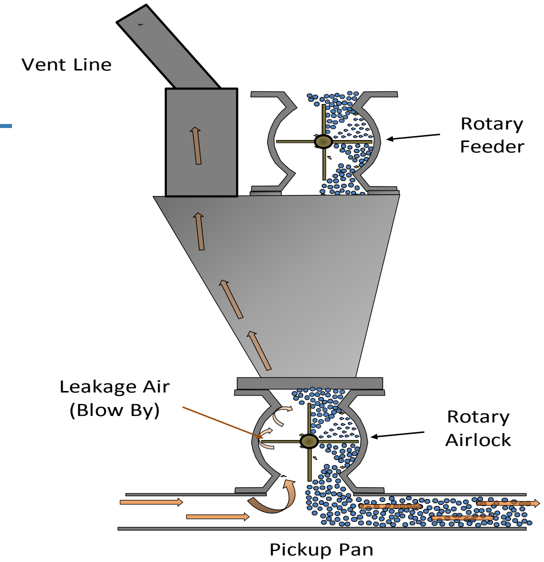
1. Air in returning pocket
2. Clearance leakage
3. Gaps between valve and housing

➢ Use a venting system

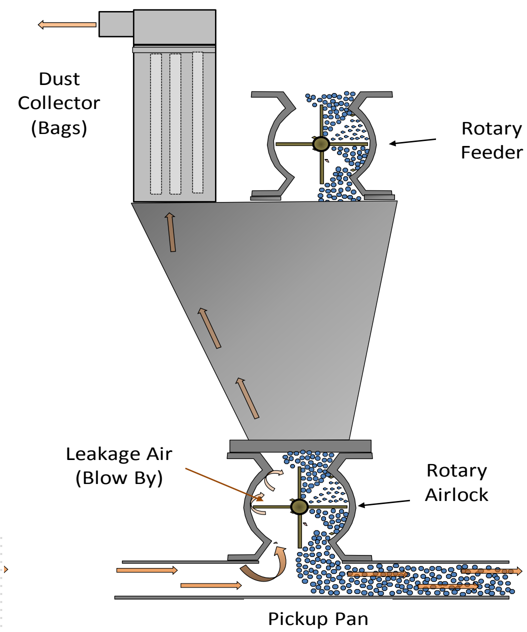
VENTED SURGE HOPPER



Vent line



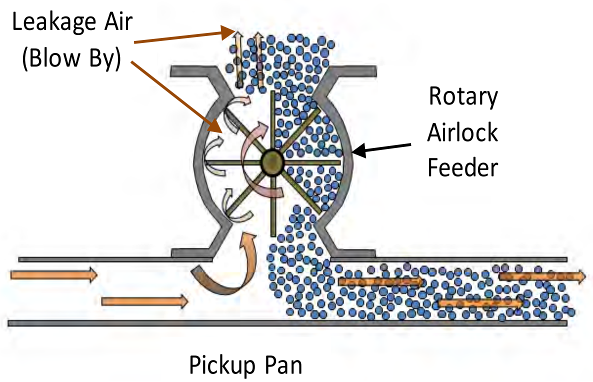
Dust collector



LEAKAGE AIR AS A RESULT OF EXCESSIVE WEAR

Over time, valve body and rotor vanes develop wear

1. Abrasive
2. Erosive



Result: Reduction in conveying air velocity

1. Product deposits in conveying line
2. Gradual increase in conveying air pressure
3. Periodic spikes in conveying pressure

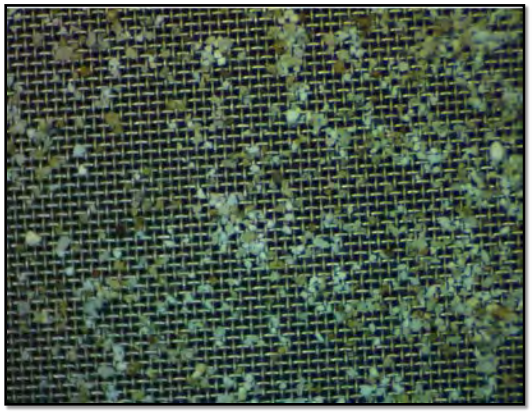
Scoring
Vane edge
Housing wall

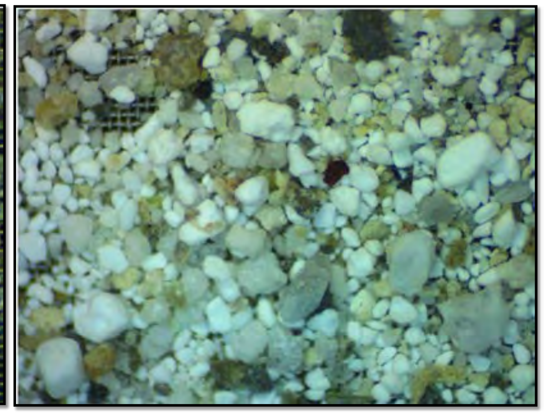
COARSE HYDRATED LIME WILL INCREASE VALVE WEAR

Grit and large particles will accelerate wear on rotary feeders and lead to conveying issues

Microscopic Comparison

Refined hydrate vs Coarse, large particle size hydrate





Background screen is 325 mesh (44 microns)

Retained 325 mesh screen low residue hydrate

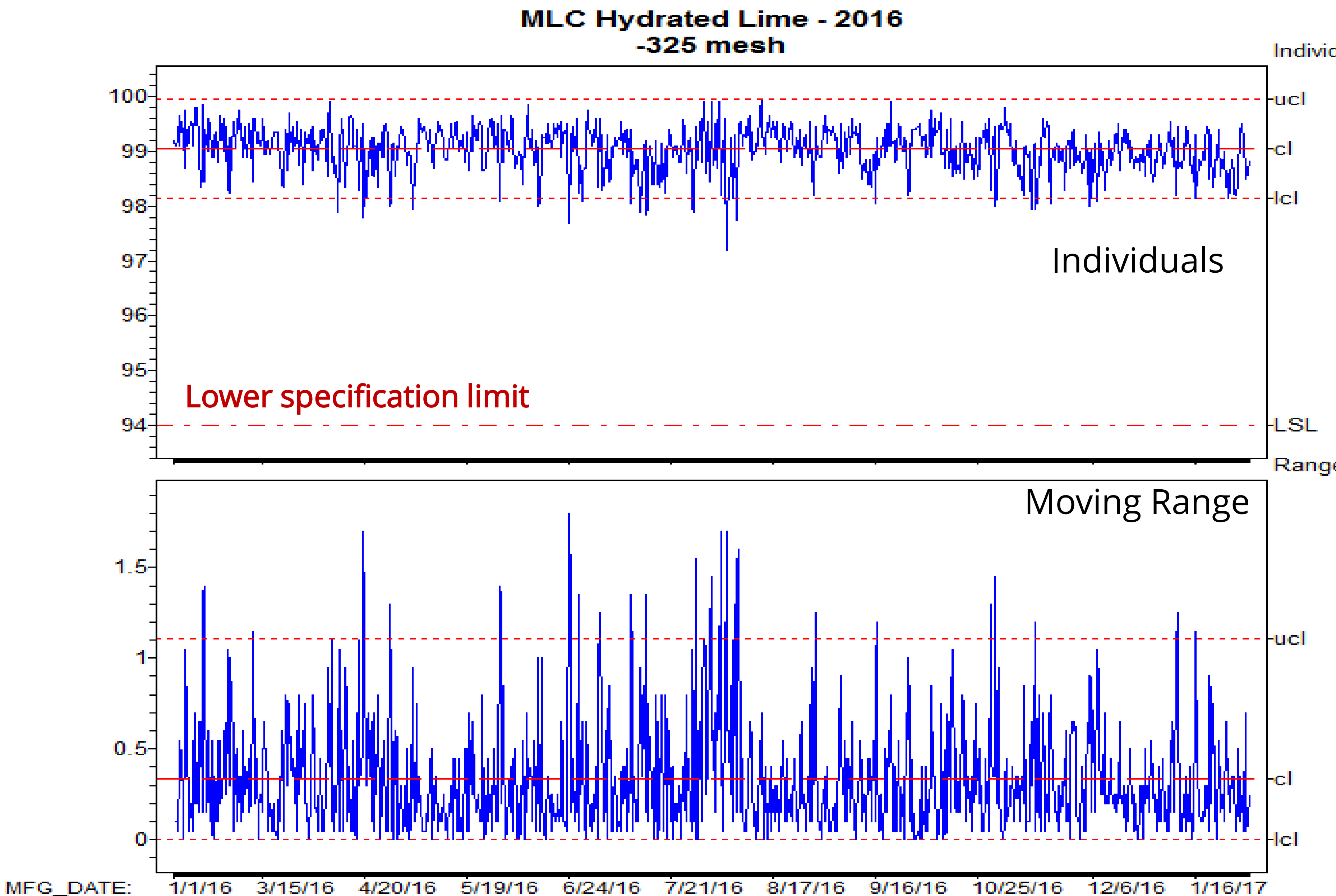
Retained 325 mesh screen high residue hydrate

WEAR ON FEEDER VANES

- Loss of conveying air flow
  - Dry powder plugs between splitter and lances
  - Pressure spikes in conveying air

- Good idea to check rotary feeders during outages
  - Swap out rotors
  - Refurbish existing rotors for spare

CONSISTENT PRODUCT = CONSISTENT FLOW PROPERTIES

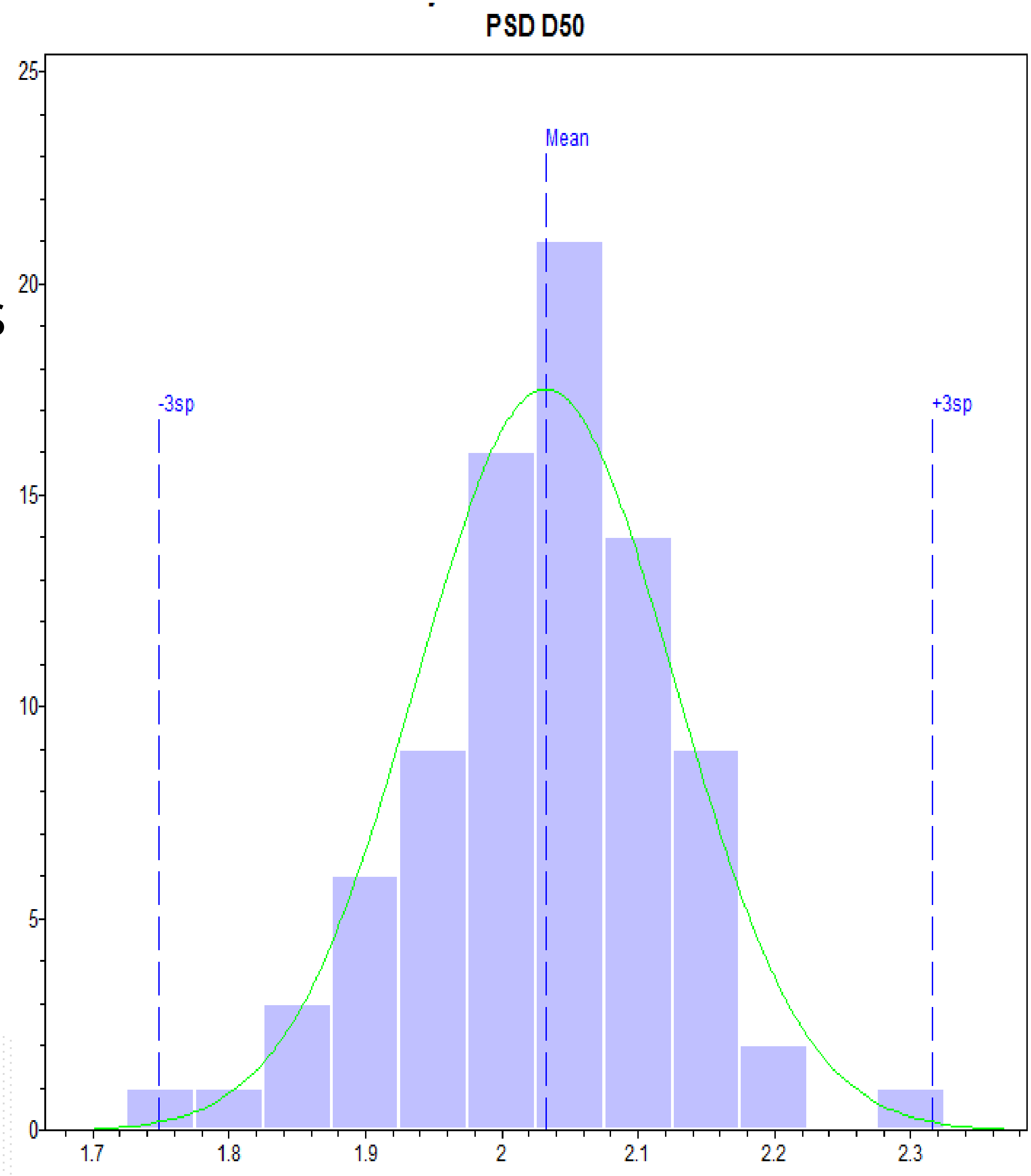


CONSISTENT PRODUCT = CONSISTENT FLOW PROPERTIES

Particle Size

- Example shows tight control over manufacturing process
  - ➢ Flow consistency

- Wide variations in D50 ($\sigma > 0.5$) indicative of variability in manufacturing and flow properties



KEYS TO HYDRATED LIME DSI SYSTEMS

- Conveying air quality and quantity
- Consistent release from silo cone
- Properly selected and designed rotary airlock feeder
- Understand effects of the hydrate being fed
- A reliable, well-designed DSI system is key to maximizing the value from your Air Pollution Control system

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